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TITLE OF THE INVENTION

CAMERA

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This application is based upon and claims the  
benefit of priority from the prior Japanese Patent  
Application No. 2000-401291, filed December 28, 2000,  
the entire contents of which are incorporated herein by  
reference.

BACKGROUND OF THE INVENTION

10 1. Field of the Invention

The present invention relates to a camera with  
an image pickup device, and in particular to a camera  
where dust adhering to an interior of the camera can be  
removed.

15 2. Description of the Related Art

Conventionally, a relatively large pixel pitch has  
been applied to an image pickup device. In recent  
years, however, in a case that a small sized image  
pickup device with one million or more pixels is used  
20 in a camera, there occurs a problem that the pixel  
pitch becomes fine and a shadow of dust adhering to an  
optical element face in the vicinity of an image pickup  
face of the image pickup device is picked up by the  
image pickup device so that the image quality of the  
25 obtained photograph is considerably affected by the  
shadow, which results in deterioration of image  
quality.

As one of methods for solving the problem, such a structure is employed that an image pickup device section is sealed as closely as possible, or as another of the methods, such a procedure is employed that in a single-lens reflex camera of a lens exchangeable type, a lens is detached from a main body of the camera, and an image pickup device section is exposed using a special operation mode so that dust adhering to the image pickup device section is blown out by a blower or the like.

In the former method, however, in a case of a camera having a mechanism with a mechanical focal-plane shutter, the shutter itself must be closed tightly or sealed and a sealing structure therefor is much complicated, which results in large size. Also, even when the outside of the shutter is sealed, there occurs a problem that a surface of the shutter is worn due to sliding operation of a plane of the mechanical shutter to generate dust, and the generated dust adheres to the image pickup device section. Also, in a case of a shutter constituted so as to control the image pickup device electrically instead of the mechanical shutter, there is a drawback that a time required for driving the image pickup device is prolonged due to a shutter control, which causes increase in temperature of the image pickup device so that the image quality of a photograph obtained by the camera or a life of

a battery cell in the camera is reduced.

Furthermore, in the another method, such  
a complicated operation is required that an exchange  
lens is detached for blowing dust, or the image pickup  
5 device is exposed in a special mode. Also, when the  
mechanical shutter is used, the shutter must be put in  
an opened state during removal of dust. At this case,  
when the shutter is closed unexpectedly due to voltage  
shortage or the like, a blower for cleaning and the  
10 shutter plane are brought into contact with each other  
so that the shutter may be damaged.

#### BRIEF SUMMARY OF THE INVENTION

In view of the above circumstances, an object of  
the present invention is to provide a camera having  
15 a dustproof mechanism for an image pickup device which  
is effective against dust generated after assembling  
the camera, where the dustproof mechanism can be made  
simple and small-sized by constituting a sealed portion  
of an image pickup device section in a small size.

20 According to an aspect of the present invention,  
there is provided a camera comprising: an image pickup  
optical system for forming an optical image of  
an object; a photoelectric converting device for  
converting the optical image to an electric signal;  
25 an optical device disposed between the image pickup  
optical system and the photoelectric converting device;  
and vibration applying means for vibrating the optical

device.

According to another aspect of the invention,  
there is provided a camera according to the above  
aspect, further comprising a holding member sealing  
5 between the optical device and the photoelectric  
converting device.

According to still another aspect of the  
invention, there is further provided a camera according  
to the above aspects, wherein the vibration applying  
10 means applies one of bending standing wave vibrations  
and oval vibrations to the optical device.

Additional objects and advantages of the invention  
will be set forth in the description which follows, and  
in part will be obvious from the description, or may  
15 be learned by practice of the invention. The objects  
and advantages of the invention may be realized and  
obtained by means of the instrumentalities and  
combinations particularly pointed out hereinafter.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

20 The accompanying drawings, which are incorporated  
in and constitute a part of the specification,  
illustrate embodiments of the invention, and together  
with the general description given above and the  
detailed description of the embodiments given below,  
25 serve to explain the principles of the invention.

FIG. 1 is a sectional view of a camera according  
to a first embodiment of the present invention;

FIG. 2A is a perspective view of a dustproof device section according to the first embodiment and FIG. 2B is a pattern diagram of an electric terminal for ground of the dustproof device section shown in FIG. 2A;

FIG. 3A is a circuit diagram for applying a signal to a dustproof device according to the first embodiment;

FIG. 3B is a diagram of a glass plate and a piezoelectric member of the dustproof device viewed from a direction of arrow A in FIG. 3A, and FIG. 3C is a diagram showing bending vibrations of the glass plate shown in FIG. 3B;

FIG. 4 is a diagram showing an anti-static constitution of a transparent electrode according to the first embodiment of the present invention;

FIGS. 5A to 5I are diagrams showing behaviors of dust adhering to a surface of a vibrating glass plate according to the first embodiment of the present invention;

FIG. 6 is a diagram showing a dustproof device section according to a second embodiment of the present invention;

FIG. 7 is a diagram of a progressive wave according to the second embodiment of the present invention; and

FIG. 8 is a diagram showing a dustproof device

section according to the second embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will be explained below with reference to the drawings.

FIG. 1 is a sectional view of a camera showing a first embodiment of the present invention, where only a main portion of the camera is shown. A type of a camera used herein is a single-eye reflex type camera of a lens exchange type, which comprises a lens assembly 1 and a camera body 10. The lens assembly 1 and the camera body 10 are coupled to each other, for example by a coupling mechanism such as a bayonet or the like. Also, the lens system 1 has an image formation lens system 2, and an image formation position can be adjusted by moving the entire of the image formation lens system 2 or one or some lenses constituting the image formation lens system 2 in a direction of an optical axis. The lens assembly 1 is also provided with a focus adjusting mechanism (not shown).

In FIG. 1, also, light rays of an object image passing through the image formation lens system 2 are turned upwardly by a mirror 11 and an optical image of the object image is formed on a screen 12. The optical image can be observed via a roof prism from an eye piece 14.

On the other hand, an image pickup face of a CCD (Charge Coupled Device) 15 serving as an image pickup device in the camera according to the embodiment, which is a photoelectric transfer device, is arranged at  
5 a position optically equivalent to the image formation face of the screen 12. The CCD 15 is held in a holder 151 which is a holding member such that the image pickup face faces an opening portion 151a of the holder 151, and a support portion (not shown) of the holder  
10 151 is fixed to the camera body 10. Also, a mask 152 having a rectangular opening is provided in front of the CCD 15 and it defines a light receiving range of a light receiving face of the CCD 15. Furthermore, a filter H 153 which is an optical low pass filter for  
15 a reference direction, a filter V 154 which is an optical low pass filter for a direction perpendicular to the reference direction, and a filter R 155 which is an infrared ray insulating filter are respectively provided in front of the CCD 15.

20 In a conventional camera, the above-mentioned structure is employed, where a front face of the filter R 155 is exposed to a space on the side of a shutter 16. Accordingly, dust which has invaded into an inside of the body 10 or has been generated in the inside  
25 adheres to an exposed face of the filter R 155, and the shadow of the adhered dust is not blurred sufficiently because the exposed face and the image formation face

of the CCD 15, so that the shadow is recorded as an image projected on the image pickup face.

In this embodiment, a glass plate 17 which is an optical device is fixed to the holder 151 via a supporting body 18 so as to cover the opening portion 151a, and the filter R 155 is sealed or closed tightly by sealing a space between the glass plate 17 and the supporting body with a visco-elastic filler. This is because, by using the visco-elastic filler, vibrations of the glass plate 17 can be prevented from being transmitted to another member and vibrations of the glass plate 17 itself are not obstructed. In this manner, since the glass plate 17 is arranged so as to cover the opening portion 151a of the holder 151, a space between the CCD 15 and the glass plate 17 is sealed by the holder 151 and the glass plate 17 so that dust is prevented from invading into the space from the outside. Accordingly, by assembling these members in a state where dust is removed from these members, the face of the glass plate 17 positioned on the side of the filter R 155 is prevented from being adhered with dust. Then, piezoelectric bodies a 171 and b 172 are fixed to upper and lower portions of a back face of the glass plate 17 to constitute a dustproof device 170.

Next, FIG. 2A is a perspective view of a dustproof device section, and FIG. 2B shows a pattern of an electric terminal 173 for ground of the piezoelectric



bodies provided to the glass plate 17 in a fixing manner. An image formation light ray passing-through area 17a through which a light bundle from the image formation lens system 2 passes is formed at almost  
5 a central portion of the glass plate 17. The light bundle from the image formation lens system 2 passes through the image formation light ray passing-through area 17a to be incident on the CCD 15. Also, supporting bodies a 181 and b 181 made of material such  
10 as rubber having a vibration absorbing characteristic are fixed to left and right portions of the glass plate 17. Each supporting body is provided with a joining portion recessed towards the side of the glass plate 17 by one step size, left and right portion of the front  
15 face of the holder 151 are received in the joining portion, and the holder 151 and the supporting body are fixed to each other at the joining face. Also, a lead wire G 174 connecting to the ground is welded to the electric terminal 173. Furthermore, the piezoelectric  
20 bodies a and b are respectively provided with a lead wire Sa 174 and a lead wire Sb 175, and they are applied with a cyclic voltage. Also, the electric terminal 173 may be formed by adhering an electric conductive thin film to the glass plate 17 or it may  
25 be formed by performing such a vapor deposition as a sputtering process or an electroless plating on the glass plate 17.

Next, FIG. 3A shows a schematic circuit diagram for applying a signal to a dustproof device. As shown in FIG. 3A, the piezoelectric body a and the piezoelectric body b are polarized to the same orientation in the direction of the thickness of the piezoelectric body (a direction of the optical axis of the image formation lens 2) and cyclic voltage is applied to faces of the surface sides of the piezoelectric bodies. Such a cyclic signal may be a rectangular wave or a sine wave.

Next, FIG. 3B is a view of a state of the dustproof device obtained when a cyclic signal is applied to the dustproof device, which is viewed from arrow A in FIG. 3A. As shown in FIG. 3B, a solid line shows a case where a voltage is not applied to the dustproof device, a chain on the lower side shows a case where the piezoelectric bodies are stretched by applying + (plus) voltage to the piezoelectric bodies, and a chain line on the upper side shows a case where the piezoelectric bodies are shrunk by applying - (minus) voltage to the piezoelectric bodies.

Next, FIG. 3C shows a bending vibrations occurring at a face of the glass plate 17 of the dustproof device which is vibrating as shown in FIG. 3B, which is positioned on the side of the shutter 16. The arrow shows a locus a mass point on a surface of the glass plate 17. The mass point on an antinode of the bending

vibration is vibrated up and down, and it has a maximum amplitude. Also, the amplitude of the mass point is zero at a position of a node of the bending vibration where the mass point acts only a rotational motion.

5 Between the antinode and a node of the bending vibration, the mass point and a portion positioned from the mass point close to the node vibrate about the node in an arc shape.

10 Next, FIGS. 5A to 5I show the behaviors of a dust according to a time sequence in a state that the dust adheres to a surface of a glass plate before a surface of the glass plate vibrates. FIGS. 5A to 5I show a case that, in addition to the vibration of the glass plate, such a force as gravity acts on the dust in the  
15 direction of the plate thickness of the glass plate.

First, FIG. 5A shows a state that a dust adheres to a surface of a glass plate before the surface vibrates. In a state shown in FIG. 5B, the surface starts to vibrate and a force shown with an arrow is  
20 applied from the surface to the dust. In a state shown in FIG. 5C, the force acting on the dust becomes weak but a force shown with an arrow is applied on the dust. In a state shown in FIG. 5D, a vibration direction is reversed from the state shown in FIG. 5C, and when  
25 an inertial force acting on the dust from the surface exceeds an adhering force of the dust to the surface and the gravity, the dust separates from the surface to

continue inertial movement between the state shown in FIG. 5C and the state shown in FIG. 5D. Then, broken lines shown in FIGS. 5D to 5F show movement loci of the dust when a downward force (gravity, electrostatic force or the like) in these figures is applied to the dust. Then, as shown in FIG. 5F, the dust is consequently moved leftward from the state shown in FIG. 5A.

The reason why the dust is moved in this manner is that the vibration of the mass point shown in FIG. 3C has a horizontal component. Also, in the course from a state shown in FIG. 5H to 5I, the dust is applied with a force from the surface, again.

In this manner, FIGS. 5A to 5I show movement of a piece of dust during one cycle of the vibration, but when the vibration is further continued, dust gathers together at the node of vibration shown in FIG. 3C. Also, even when dust adheres to the position of the antinode of vibration, since it will be impossible that the dust is formed in a complete sphere and its center of gravity is positioned at the antinode of vibration accurately, when the dust separates from the surface and it adheres to the surface again, the dust deviates from the position of the antinode so that it is finally moved to the node of vibration. Accordingly, when bending vibration is generated such that a node of vibration is positioned so as to be deviated from the

image formation light ray passing-through area, dust  
can be removed from the image formation light ray  
passing-through area. Also, in the present invention,  
such a constitution is employed that respective nodes  
5 of vibration are supported by the supporting body a and  
the supporting body b. With such a constitution, since  
each node is supported at a position having amplitude  
of zero, an effective supporting method can be provided  
which does not prevent bending vibration. Further,  
10 the bending vibration can produce a large amplitude at  
a signal of the lowest voltage when resonance occurs.  
The resonance frequency at this time is determined  
according to the shape and the material quality of the  
dustproof device, a supporting method, and a vibration  
15 mode.

Now, assuming that the dustproof device has  
a simple rectangular plate, the length of the long side  
of the plate is  $l$ , the plate thickness is  $h$ , the  
longitudinal elastic coefficient of the plate is  $E$ ,  
20 the density of the plate is  $\rho$ , and a primary bending  
vibration as shown in FIG. 3C is produced through  
a free support serving as the support, the resonance  
frequency  $f$  is:

$$25 \quad f = \frac{1.133\pi}{l^2} \sqrt{\frac{Eh^2}{12\rho}}$$

In FIGS. 5A to 5I, the gravity is applied to the  
face in a vertical direction to the face, but when the

gravity is applied in an in-plane direction, dust moves in a direction of the node of the bending vibration and it also moves in a direction of the gravity, so that it is removed from the image formation light ray passing-through area.

Thus, in this embodiment, a voltage is applied at a frequency at which the glass plate 17 which is the dustproof device is resonated.

By producing a primary bending vibration in the glass plate 17 which is the dustproof device in the above manner, dust adhering to a surface of the glass plate 17 can be removed from the surface. However, in a case that a surface of the glass plate 17 is charged with static electricity, dust which has adhered on the surface of the glass plate 17 is attracted on the surface of the glass plate 17 by static electricity. Accordingly, when an attracting force is much strong, dust on the surface of the glass plate 17 may not be removed therefrom. In order to solve this problem, as shown in FIG. 4, a transparent electrode 41 and an electric terminal 44 conductive to the transparent electrode 41 are formed on the surface of the glass plate 17, and the transparent electrode 41 is grounded through the electric terminal 44 so that the glass plate 17 can be prevented from being charged. Then, the piezoelectric bodies 42, 43 are constituted on a surface of the glass plate 17 which is positioned on

the side of the CCD 15, as shown in FIG. 3A, and such a vibration as mentioned above is applied to the glass plate 17, so that dust adhering on the surface of the glass plate 17 can be removed from the surface.

5           As mentioned above, by providing an anti-static means for preventing the surface of the glass plate 17 from being charged, more effective dust removing effect can be achieved. Also, besides such a constitution that the surface of the glass plate 17 is grounded for  
10 preventing the charging, an effect similar to the case of grounding can be achieved by applying an anti-static coating on the surface of the glass plate 17.

Next, FIG. 6 shows a second embodiment of the present invention. As shown in FIG. 6, a dustproof  
15 device generating a progressive wave on a glass plate 27 is constitute by fixing piezoelectric bodies a1 271, a2 272, b1 273 and b2 274 on the glass plate 27 and providing an electric terminal for grounding between each piezoelectric body and the glass plate. Each  
20 piezoelectric body has sections (expressed by symbols + and -) with different polarization directions which are arranged alternately in a horizontal direction. Assuming that horizontal polarization arrangements of the piezoelectric body a1 271 and the piezoelectric  
25 body b1 273 are the same, and a section length of the + section and - section is defined as  $\lambda$ , the remaining piezoelectric bodies a2 272 and b2 274 are arranged

such that they are shifted from the arrangement positions of the two piezoelectric bodies a1 and b1 by  $\lambda/4$  in a horizontal direction.

Cyclic voltages having the same phase are applied to the piezoelectric bodies a1 and b1 from an oscillator, respectively, while cyclic voltages whose phases have been shifted by  $90^\circ$  through a  $90^\circ$  phase shifter are applied to the piezoelectric bodies a2 and b2 from the oscillator. With such a configuration, as shown in FIG. 7, a progressive wave with a wavelength  $\lambda$  is generated on the surface of the glass plate 27. FIG. 7 is a diagram of the surface of the glass plate 27 shown in FIG. 6, which is observed when the surface is viewed from a direction of arrow B, where a one-dotted line denotes the shape of the surface just after a voltage is applied and a double-dotted line denotes an aspect where a bending vibration wave progresses in a horizontal and rightward direction according to a time lapse.

As mentioned above, when a progressive wave occurs on the glass plate, an oval vibration (including a circular motion) in a counterclockwise direction occurs at any mass point, as shown in FIG. 7. Since there is a leftward and horizontal component in the oval vibration, all dust adhering to a surface of the glass plate are conveyed to the left side of the glass plate.

In the second embodiment of the present invention,



since dust is collected to one side of the glass plate,  
disposition of the collected dust can be made more  
simply than that in the first embodiment. Also, since  
the amplitude of the oval vibration is the same at any  
5 portion of the glass plate, a force for removing dust  
becomes uniform over the entire surface of the glass  
plate. Also, in a case of the second embodiment, the  
amplitude of a progressive wave can be made large by  
resonating the bending vibration, so that an inertial  
10 force for removing dust can be increased. Furthermore,  
as compared with the first embodiment, the second  
embodiment of the invention has a merit that, since  
a vibration having a wavelength of about  $1/3$  the  
wavelength of the first embodiment is used, it exceeds  
15 a audible range so that operational sound such as noise  
is not heard. Also, as another embodiment, such a  
constitution can be employed that a progressive wave  
shown in FIG. 6 is not produced in a direction of the  
longitudinal side of the rectangular glass plate but it  
20 is produced in a direction of the short side thereof.  
In this case, since the length to be vibrated is  
shorter than that in the case that the progressive wave  
is produced in the direction of the longitudinal side,  
a further short wavelength can be employed. Also, as  
25 still another embodiment, such a constitution can be  
employed that a progressive wave is produced in an  
orthogonal direction of the rectangular glass plate

and dust is collected at a corner of the glass plate, so that collection or recovery of the dust can be made easy.

Next, FIG. 8 is a perspective view of a dustproof device of a third embodiment of the present invention. A supporting body 38 formed of a rubber having a vibration damping property or the like is fixed to a glass plate 37 and a front face of a holder 151 (not shown) is bonded to a holder butting face 381 in a butting manner therewith. A laminated piezoelectric body a 371 and a laminated piezoelectric body b 372 are fixed to the glass plate 37 outside the supporting body 38, and the respective laminated piezoelectric bodies are fixed with a weight a 373 and a weight b 374 made of material having a relatively large specific gravity, such as, for example, tungsten, copper, or iron.

Cyclic voltage is applied to each laminated piezoelectric body from an oscillator and each of the weights a 373 and a 374 is vibrated in a direction of an optical axis of a lens. The glass plate 37 can be vibrated in the direction of the optical axis by reaction force of the weight. Dust on the surface of the glass plate can be released from the surface by the vibration of the glass plate, so that, when vibration is applied to the glass plate in an in-plane direction in which the gravity acts, dust is removed in a direction in which the gravity acts. Also, such

a constitution can be employed that an air flow is produced simultaneously with application of the vibration instead of the gravity so that dust is removed by action of the air flow. Any vibration which can achieve a similar effect can be employed in this invention.

In the dustproof device of the third embodiment, the dustproof device of the first embodiment can be formed by attaching a laminated piezoelectric body or a dustproof device in the vicinity of the antinode of the bending vibration of the first embodiment and oscillating the oscillator at a resonance frequency. In this case, as the position where the laminated piezoelectric body is attached, any position other than the position of a node of the bending vibration can be selected. However, a bending vibration can be produced more effectively by attaching the laminated piezoelectric body in the vicinity of the antinode. Similarly, even in a case that laminated piezoelectric bodies with a weight are fixed to positions which are shifted each  $\lambda/4$  in a horizontal direction and a phase is shifted by  $90^\circ$  in a time manner, when a cyclic voltage of a resonance frequency of the above-mentioned bending vibration (a bending vibration of 1.5 wavelength in a standing wave) is applied, the bending progressive wave shown in FIG. 7 occurs in the glass plate.

Even in the second and third embodiments thus configured, anti-static means such as explained in the first embodiment is provided, so that an effect for removing dust can be enhanced.

5 Further, the following aspects can be considered.

#### ADDITION OF VARIOUS ASPECTS

1. According to a first aspect of the present invention, there is provided a camera comprising: an  
10 image pickup optical system for forming an optical image of an object a photoelectric converting device for converting the optical image to an electric signal; a holding member which holds the photoelectric transfer device and has an opening portion which guides lights from the image pickup optical system to the photo-  
15 electric transfer device; an optical device which covers the opening portion and seals the photoelectric transfer device; and a vibration generating device which vibrates the optical device, wherein the optical device is attached to the holding member in the  
20 vicinity of a node of vibration produced by the vibration generating means.

2. According to a second aspect of the invention, there is a provided a camera according to the first aspect, where the optical device is a low-pass filter.

25 3. According to a third aspect of the invention, there is provided a camera according to the first aspect, wherein the optical device is an infrared

100-50000

isolating filter.

4. According to a fourth aspect of the invention, there is provided a camera according to the first aspect, further comprising a light permeable electrode  
5 formed on a surface of the optical device opposed to the photoelectric converting device; and grounding means which is electrically connected to the electrode to prevent the surface of the optical device from being charged.

10 5. According to a fifth aspect of the invention, there is provided a camera according to the first aspect, wherein the optical device has a rectangular shape, and opposed sides of one of two sets are fixed to the holding member while adhesive with elasticity is  
15 filled in a space between opposed sides of the other and the holding member.

6. According to a sixth aspect of the invention, there is a camera according to the first aspect, wherein the node of vibration is positioned outside  
20 an effective permeable range of the light permeable electrode.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to  
25 the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the

spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.